



REVIEW ARTICLE

The Medicinal Properties of *Paullinia pinnata* Linn. Leaves

Oluwatoyin A Adeyemo-Salami

Abstract

Paullinia pinnata is a plant introduced to tropical Africa and has been reported to be useful in folkloric medicine. Different medicinal potentials of the leaves have been investigated some of which have corroborated reports in traditional medicine. Compounds have been isolated from extracts of the leaves which have been shown to have medicinal value. These compounds are from different classes of secondary metabolites including tannins, flavonoids and alkaloids. Fatty acids have also been shown to be present. This report is set to enumerate the traditional use of the leaves of *P. pinnata* and research findings already documented.

Keywords: *Paullinia pinnata* leaves; folkloric medicine; experimental findings; isolated compounds

Introduction

Mankind has been plagued with various diseases from time immemorial. As a result of this, man has exploited various means to circumvent these health challenges. The chief means has been the use of plants in his environment an example of which is *Paullinia pinnata* [1, 2].

Paullinia pinnata is a wood or sub-woody climber of the family Sapindaceae. It originates from tropical America and is now common in the savanna zones of tropical Africa and Madagascar. The common names are “bread and cheese plant”, and “sweet gum”. The local names include: Yoruba; Kakansenla or Ogbe-okuje, Edo; Aza, Igala; Egwubi, Omekpa, Nupe; Enu Kakanchela, Hausa; Goorondoorinaa, Liberia (Basa); Gbe-se, Togo(AnyiAnifo); Tolundi, Sierra Leone (Kono); Kamakagu and Ghana(AdangmeKrobo); Akplokinkpa [3, 4].

The belief is that the plant was introduced to Africa as a fish-poison, where it is used to serve as chewing-sticks, tying fences, hut building as well as for medicinal purposes which include the treatment of rickets, leprosy, fever debility, post-partum pain, lo-

calized pain, infectious diseases, cough, whooping cough, eye ailments and in complex treatments for jaundice and yellow fever [3].

Folkloric Medicine and Experimental Findings on *Paullinia pinnata* Leaves

The leaf is claimed traditionally to be a general panacea. In folklore medicine, it finds use in various forms for the treatment of colic, dysentery and diarrhoea [5]. Though the leaf is widely used as an anti-diarrhoeatic in Africa, it is administered as a purge among the Igala tribe and Esan people of Nigeria [1, 6]. The leaf has also been shown to be useful gynaecologically. In various preparations, the leaf is taken to prevent miscarriage. In Ivory Coast, Tanzania and Gabon, the leaf is used as an ocytote to ease child birth. In Congo, it is used as a lactogene and also to help sterility. In Gabon and Ghana, it is used to ease menstrual discomfort [3, 7].

The leaf is used on contusions in Ghana and Nigeria; aches, sprains, fractures, dislocations and burns in Ghana; sores in Nigeria, Mali and Ivory Coast; stiffness and lumbago in Mali; rheumatism in Nigeria; internal and external swellings in the Gambia; dermatological aberrations throughout West and Cen-

Correspondence: soluwatoyin81@gmail.com@yahoo.com

Department of Biochemistry, College of Medicine, University of Ibadan, Nigeria

Full list of author information is available at the end of the article.

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tral Africa and topically for treating ulcers in Ivory Coast and Ghana [3, 8, 9].

Other medicinal applications include the treatment of fevers in West Africa and in particular malaria in Tanzania. Also used for the treatment of gonorrhea and paralysis in East Africa; eye treatment and leprosy in Ivory Coast; rickets in Ghana and Ivory Coast; colds in general in Nigeria; tetanus in Ghana; anti-anaemic tonic and bile stimulant in Nigeria, Congo and Senegal; snake bite in East Africa and ancylostomiasis in Tanzania. In Ghana, a leaf decoction is considered an aphrodisiac [3, 7]. Focho et al. [10] reported that the leaves of *P. pinnata* are taken orally in a concoction with the inflorescence of *Musa sapientia* to treat syphilis. Addo-Fordjour et al. [11] documented that the roots were used as chewing stick or in other preparations for the treatment of impotence and rheumatism while Agyare et al. [9] reported that the roots and leaves were used as poultice for the treatment of new, old and chronic wounds as well as in treating haemorrhoids.

The leafy twigs, root, flowers, fruit and seeds are used for similar medicinal purposes as the leaves throughout Africa. Proximate analysis is reported to be 4.9 % of protein, 3.5 % of fat and 86.7 % of carbohydrate. The fruit contains a gum used by children for sticking papers together. Moreover, there are fetish claims attributed to the plant. In Ivory Coast, a wash in the decoction is believed to confer protection against evil [3].

Scientific investigations have been carried out on the leaves of *Paullinia pinnata* and they are well documented.

Toxicology Studies

Adeyemo-Salami and Makinde [12] determined the safe dose for the methanol extract of the leaves to be 200 mg/kg using male Wistar rats. Nnah and Uche [13] determined the LD₅₀ of the ethanol leaf extract to be 1190 mg/kg, ED₅₀ of 750 mg/kg and therapeutic index of 1.85 in mice. Moreover, Lunga et al. [14] observed that after administration to Wistar rats of both sexes with methanol leaf extract of *P. pinnata* to treat *Salmonella typhimurium*-induced typhoid, the female rats were adversely affected at the various doses of treatment while the male rats were particularly affected at the high dose (446 mg/kg) as revealed by the biochemical analysis and altered relative organ weight.

Antibacterial capacities

Ikhane et al. [4], using *in-vitro* and *in-vivo* assays, showed that the methanol extract had antimicrobial activity against food-borne pathogens which were *Pseudomonas aeruginosa* and *Staphylococcus aureus*. Thus having effect on both gram-negative and gram-positive bacteria and therefore having a broad spectrum potential. This finding supports the work of Annan and

Houghton [15] who showed that aqueous decoction of leaves, stem and root of *P. pinnata* had activity against *Staphylococcus aureus* and *Bacillus subtilis*. Roger et al. [16] also demonstrated the activity of ethanol extract of *P. pinnata* against fresh clinical strains of *Salmonella typhi* ATCC 6539, *Salmonella paratyphi A* and *Salmonella paratyphi B*.

Pharmacological presentations

A flavotannin isolated by Bowden was shown to have cardiotonic action on isolated perfused frog heart [17]. Aqueous ethanol extract of the leaves have been shown to have anti-malarial property [18]. However, Adeyemo-Salami et al. [19] showed that the methanol extract did not possess curative potential against chloroquine-resistant *Plasmodium berghei* NK 65 when taking into consideration a safe dose. Ior et al. [20] showed in Wistar mice and rats that the aqueous ethanol extract of the leaves possess anti-inflammatory and analgesic properties thus supporting its use in traditional medicine for the treatment of rheumatism and arthritis, which are as a result of inflammation and pains. Patience et al. [21], using aqueous leaf extract, revealed in cotton pellet-induced granuloma rat model and complete Freud's adjuvant induced-oedema rat model the anti-inflammatory roles. Furthermore, using behavior pain model in mice and anti-inflammatory with carrageenan, dextran, histamine and serotonin-induced inflammation in rats, analgesic and anti-inflammatory effects of aqueous extract of *Paullinia pinnata* leaves were assessed by Patience et al. [22]. Their results suggested that the extract possessed analgesic properties which may interfere in both central and peripheral pathways. They also concluded that the anti-inflammatory potential may be mediated by either inhibiting or blocking the release of vasoactive substances like prostaglandins, serotonin, kinins and histamine. Aliyu et al. [23], using the elevated plus-maze test and staircase paradigm, showed in Swiss mice that the methanol leaf extract had anxiolytic property and could therefore be considered for clinical application in the management of anxiety disorders subject to further investigation. Nnah and Uche [13], using normotensive adult cats, suggested that the mean arterial blood pressure lowering effect of the ethanol leaf extract of *P. pinnata* was as a result of it binding to the numerous muscarinic and histaminergic receptors in the cardiovascular system.

Antioxidant properties

Zamble et al. [24] also showed that the methanol extracts of the leaves and root had *in-vitro* scavenging activity against superoxide oxygen (O₂⁻), hydrogen peroxide (H₂O₂) and hypochlorous acid (HOCl). Jimoh et al. (2007), also confirmed the scavenging activity of the plant on 1,1-diphenyl 1-2-picryl hydrazyl (DPPH) and 2,2-azino-bis-3-ethylbenzothiazoline-6-sulfonic acid radi-



Figure 1 *Paullinia pinnata* Linn. Leaves

cals *in-vitro* which was confirmed by Lunga et al. [25]. The plant was also shown to possess moderate ferric reducing potential [26]. Using 2,2-diphenyl-picrylhydrazyl (DPPH) bleaching assay, Trolox equivalent antioxidant capacity (TEAC) assay and Hemoglobin ascorbate peroxidase activity inhibition (HAPX) assay, Tamokou et al. [27] showed that hexane extract of the leaves possess antioxidant capacity *in-vitro*. All these indicate that *P. pinnata* is a potential source of natural antioxidants.

Anticancer, haematological and antityphoid effects

Tamokou et al. [27] showed that the hexane extract inhibited the growth of the p53 wild-type malignant melanoma cell line WM35, A431 squamous epidermal carcinoma, A2780 ovary carcinoma and cisplatin resistant-A2780cis cells. Thus suggesting that it has anti-cancer property. Adeyemo-Salami and Ewuola [28] showed that the methanol extract of the leaves had anti-anaemic property with the ability to lower neutrophils count in normal Wistar rats. This seeks to support traditional use as an anti-anaemic tonic. Anti-typhoid activity was exhibited by methanol leaf extracts in *Salmonella typhimurium*-infected Wistar rats by inducing proliferation of white blood cells and lymphocytes in the body [25].

Phytotoxic and other biological properties

Phytotoxic activity in a dose-dependent manner was reported *in-vitro* by Salami and Fafunso [29] against *Lemna minor* (Common duckweed), thus suggesting that it could be a good source of natural herbicides. The intermediate host of *Schistosoma mansoni* (the parasite responsible for schistosomiasis) is *Biomphalaria glabra*. *P. pinnata* extracts was shown to kill 50 % of the snails after a twenty-four hour exposure and a day for recovery [30]. Zamble et al. [24] showed that *P. pinnata* extracts had the capacity to induce endothelium-dependent vaso-relaxation of bovine aortic endothelial cells through the nitric oxide pathway and inhibit endothelin-1 synthesis and therefore suggested that this could be the pharmacological mechanism responsible for the efficacy in unorthodox medicine for the treatment of impotence. Osarenmwinda et al. [6] showed that the methanol extract of the leaf possesses antidiarrhoeal activity in a dose-dependent manner and inhibits gastrointestinal motility in Swiss albino mice thus corroborating or validating the folkloric use. Fred-Jaiyesimi and Anthony [31] investigated the larvicidal effects of methanol extract, petroleum ether and chloroform fractions of *P. pinnata* leaf on the third and fourth instar larvae of *Anopheles gambiae* and showed that the pet. ether fraction displayed the strongest response after 24 hours exposure, while the

methanol extract exhibited a dose-dependent effect 48 hours after exposure.

Biological activities of other parts of P. pinnata

Other investigations carried out on other parts of the plant have shown in Swiss mice that the aqueous methanol stem bark extract possesses anti-convulsant activity [32]. Lunga et al. [33] demonstrated that the methanol stem bark extract eradicated shigellosis in Shigella-induced diarrhoeal experimental rat models. The methanol stem bark extract of *P. pinnata* possessed bactericidal activity in a dose-dependent manner against *Escherichia coli*, *Pseudomonas aeruginosa*, *Salmonella typhi*, *Staphylococcus aureus*, *Protens mirabilis* and *Shigella flexneri*. This finding was complemented *in-vivo* [33]. Iful [34] also showed that extracts from the root reversed the venom-induced increase in capillary permeability in rabbits, abnormal white blood cell, platelet and packed cell volume values to normal. Spiegler et al. [35] showed in an *in-vitro* mortality assay that the aqueous ethanol root extract resulted in the mortality of *Toxocara cati*, *Trichuris vulpis* and *Caenorhabditis elegans* but did not affect *Ancylostoma caninum*. Also investigation on the effects on egg hatching and larva migration of *Haemonchus contortus* was carried out and this showed no inhibitory activity [35]. Thus supporting the traditional use of the root in anti-helminthic remedies. According to the observations of Ayim et al. [36], *P. pinnata* methanol root extract exhibited moderate anticancer activity against human cell lines; MCF-7 and DLD-1 in 3-(4,5-Dimethylthiazol-2-yl)-2,5-diphenyltetrazolium bromide (MTT) assay with IC₅₀ values ranging from 40-55 µg/ml. Annan et al. [37, 38] conducted *in-vitro* and *in-vivo* studies using human dermal fibroblast cell line 142BR and wound models in Sprague-Dawley rats. They observed that application of the methanol root extract of the plant resulted in a significant increase in 142BR fibroblast cell line proliferation. Thus showing that the extract had cyto-protective action against hydrogen peroxide-induced damage. There was also a significant increase in tensile strength and hydroxyproline content of tissues that were healing with a decrease in epithelisation period and scar area. These findings support the use of the plant in treating wounds traditionally [38].

Pure compounds from P. pinnata and their biological capacities

Lunga et al. [25] showed that (3β)-3-O-(2'-acetamido-2'-deoxy-β-D-glucopyranosyl) olean-12-en-28-oic acid, isolated from the leaf, had anti-typhoid activity against *Salmonella* species. Methylinositol was isolated from the leaves and it revealed antioxidant property using DPPH assay [25]. Annan et al. [39] revealed that the fatty acid, azaleic acid, isolated from the methanol root extract had anti-bacterial activity against gram

negative and gram positive bacteria. The gram negative bacteria were *Pseudomonas aeruginosa* and *Escherichia coli* while the gram positive bacteria were *Staphylococcus aureus* (NCTC 4163), *Bacillus subtilis* (NCTC 10073), *Micrococcus flavus* (NCTC 9743), *Streptococcus faecalis* (NCTC 775) and resistant strains of *Staphylococcus aureus* (SA 1199B, RN 4220 and XY 212). Other fatty acids isolated from the methanol root extract had weak to moderate activity against *Bacillus subtilis*, *Escherichia coli*, *Pseudomonas aeruginosa* and *Staphylococcus aureus* [39]. Annan et al. [39] also showed that the methanol extract exhibited a significant radical scavenging action in the DPPH assay but the isolated fatty acids did not. Annan et al. [40] further demonstrated in a bioassay-guided isolation of the methanol extract of the roots of *P. pinnata* that friedelin (an isolated compound) possessed a 2-fold, 4-fold and 16-fold enhancement of the activities of tetracycline, erythromycin and norfloxacin against multidrug resistant strains of *Staphylococcus aureus*; XU 212, SA 1199B and RN 4220. Imade et al. [41] revealed the antibacterial potential of the stem bark of *P. pinnata* after exposing *Staphylococcus aureus*, *Escherichia coli* and *Pseudomonas aeruginosa* to aqueous and ethanol extracts of the leaf, stem and root bark.

Lunga et al. [42] showed that some compounds isolated from the plant had antibacterial, anti-yeast and anti-dermatophytic activities. The compounds were (3β)-3-O-C2'-acetamido-2'-deoxy-β-D-glucopyranosyl), oleanolic acid, (3β)-3-O-[β-D-glucopyranosyl-C1''-3')-2'-acetamido-2'-deoxy-β-D-galactopyranosyl] oleanolic acid and (3β, 16α-hydroxy)-3-O-(2'-acetamido-2'-deoxy-β-D-glucopyranosyl) echinocystic acid respectively. Lasisi et al. [43] isolated lupeyl steryl ether, 3-oxo-11α-hydroxy-20 (29) lupen and lupeol-3-isovanilloyl ester from the methanol root extract. The lupeol-3-isovanilloyl ester, which was characterized as 3-O-isovanilloyl-3R,5R,8R,9R,10R,13R,14S,17S,18R,19R-lup-20(29)-en, showed inhibitory activity on *Escherichia coli* (NCIB 15520), *Bacillus subtilis* (NCIB 85650), *Staphylococcus aureus* (NCIB 22350), *Pseudomonas aeruginosa* (NCIB 27850), *Shigella dysenteriae* (NCIB 2350), *Clostridium sporogenes* (LIO) and anaerobic *Clostridium tetani* (LIO). The activity against *C. tetani* was the most potent (MIC 15.5 µg/ml) [43]. Moreover, Jackson et al. [44] isolated 6α-(3'-Methoxy-4'-hydroxybenzoyl)-lup-20(29)-ene-3-one, a lupine derivative.

Other compounds and phytochemicals from P. pinnata

The presence of phenolic compounds has been reported in the leaves of *P. pinnata*. A flavotannin was isolated by Bowden [17]. Abourashed et al. [45] isolated two flavone glycosides; diosmatin-7-O(2''-O-beta-D-apio-furanosyl-6''-acetyl-beta-D-glucopyranoside and tricetin-4'-O-methyl-7-O(2''-O-beta-D-

apiofuranosyl-6''-acetyl-beta-D-glucopyranoside. Tamokou et al. [27] showed that the total phenol content of the hexane extract of *P. pinnata* leaves was significant. Jimoh et al. [26] also confirmed the presence of phenolic compounds and proanthocyanidin. The presence of alkaloids, tannins, cardiac glycosides, saponins, carbohydrate, reducing sugars and anthracene have been confirmed by various researchers using phyto-chemical analysis [6, 12, 20, 46].

The cerebroside Paullinoside A and the ceramide Paullinamide A were also isolated by Miemanang et al. [47] from the leaves. Alpha-amyrin, 2-(4-hydroxy-3,5-dimethoxyphenyl)-3-hydroxymethyl-2,3-dihydro-1,4,5-trioxaphenanthren-6-one, 5 α -poriferastane-3 β ,6 α -diol, α -sitosterol, 1-quebranchitol and β -sitosterol glucopyranoside were isolated by Dongo et al. [48] from the roots of *P. pinnata*.

Phytochemical screening of other plant parts have revealed the presence of alkaloids, tannins, saponins, triterpene, phenol and sterols in the stem bark [33] In the preliminary phytochemical analysis conducted by Iful, the presence of carbohydrates, saponins, steroids and tannins was observed in extracts of the root bark [34]. Moreover, Iful showed that the root extracts contained Zinc, Calcium, Iron and Lead [34].

Annan et al. isolated and identified twelve fatty acids from methanol root extract of *P. pinnata* [39]. These included azelaic acid, palmitic acid, oleic acid, stearic acid, eicosanoic acid, docosanoic acid and tetradecanoic acid. Dongo et al. [48] isolated steroids and steroidal glycosides from the plant. Lunga et al. [42] isolated 2-O-methyl-L-chiroinositol, friedelin, (3 β)-3-O-(2'-acetamido-2'-deoxy- β -D-glucopyranosyl) oleanolic acid, (3 β , 16 α -hydroxy)-3-O-(2'-acetamido-2'-deoxy- β -D-glucopyranosyl) echinocystic acid and (3 β)-3-O-[[β -D-glucopyranosyl-(1''-3')-2'-acetamido-2'-deoxy- β -D-galactopyranosyl] oleanolic acid from the plant.

Bioinorganic element content

With the use of energy-dispersive X-ray fluorescence (ED-XRF) technique, Frimpong-Manso et al. [49] demonstrated that in the roots the presence of K, Mg, Ca and Zn (which could be responsible for the aphrodisiac potential of *P. pinnata*) was significant, and the levels of toxic elements (arsenite, cadmium, lead and mercury) were negligible. Thus buttressing the safety of the consumption. There is a possibility that a similar trend may be seen in the leaves.

Conclusion

Paullinia pinnata leaves are indeed very useful in folkloric medicine and this is well-supported by experimental findings.

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